United States Department of Agriculture
Agricultural Research Administration
Bureau of Entomology and Plant Quarantine

A REVIEW OF LABORATORY TESTS ON THE TOXICITY OF CERTAIN SEMICARBAZONES TO VARIOUS INSECTS

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In the course of its investigations the Division of Insecticide Investigations prepared a large number of semicarbazones and submitted them to other Divisions of the Bureau for laboratory tests against a number of insects. Some of these compounds seemed to be promising. Four patents have been granted on this class of compounds (3, 4, 5, 6). It was therefore considered advisable to compile the results of the tests in such a manner as to facilitate the selection of the compounds that were most toxic to any given insect and also those that were toxic to a number of different insects.

Semicarbazones may be prepared by condensing aldehydes and ketones with semicarbazide under suitable conditions. Most of them are colorless solids, which crystallize well and have physical properties that easily lend themselves to the preparation of insecticidal mixtures.

The insects tested and the Divisions in which they were tested are as follows:

Division of Cereal and Forage Insect Investigations:

European corn borer (Pyrausta nubilalis (Hbn.))

Division of Control Investigations:

American cockroach (Periplaneta americana (L.))
Bean leaf roller (Urbanus proteus (L.))
Three-striped blister beetle (Epicauta lemmiscata (F.))
Cabbage looper (Trichoplusia ni (Hbn.)) (=Autographa brassicae (Riley))
Cowpea weevil (Callosobruchus maculatus (F.)) (=C. chinensis (L.))
Cross-striped cabbageworm (Evergestis rimosalis (Guen.))
Hawaiian beet webworm (Hymenia recurvalis (F.)) (=H. fascialis (Cram.))
Imported cabbageworm (Pieris rapae (L.))
A looper (Pseudoplusia rugationis (Guen.)) (=Autographa oo (Stoll))
Melonworm (Diaphania hyalinata (L.))
Mexican bean beetle (Epilachna varivestis Muls.)
Okra caterpillar (Anomis erosa Hbn.)
Rice weevil (Sitophilus oryza (L.))
Southern armyworm (Prodenia eridania (Cram.))
Squash bug (Anasa tristis (Deg.))
A termite (Reticulitermes flavipes (K.))
Yellow woollybear (Diacrisia virginica (F.))

Division of Fruit Insect Investigations:

Codling moth (Carpocapsa pomonella (L.))

Division of Insects Affecting Man and Animals:

Furniture carpet beetle (Anthrenus vorax (Waterh.))
Mosquito (larvae) (Culex quinquefasciatus Say)
Screwworm (Cochliomyia americana C. and P.)

The methods used for testing are the usual standardized ones which have been used in the past, and so are mentioned only briefly. All the compounds tested against each insect are listed in order of toxicity. Compounds that were tested both as a dust and as a spray are listed twice. All dosages are for dusts. When no figure is given in the dosage column, the material was applied as a spray at a concentration of 8 pounds per 100 gallons unless indicated otherwise.

American Cockroach (10)

Cockroaches that were three-quarters grown were confined for 2 days in a jar on the bottom of which 0.25 gram of the compound had been dusted. The following compounds were tested: Semicarbazones of benzophenone, p-chloroacetophenone, o-chlorobenzaldehyde, cyclohexanone, cyclopentanone, 2,6-dimethyl-4-heptanone, 2,4-dimethyl-3-pentanone, 2-furaldehyde, levulinic acid, 2-methylcyclohexanone, methyl ethyl ketone, piperonal, vanillin, and o-veratraldehyde. None of these compounds showed any toxicity to the roaches.

Bean Leaf Roller

This test was carried out by feeding dusted bean leaves to fifth instars. The only compound tested was cyclohexanone semicarbazone in a dosage of 355 micrograms per square centimeter. It gave 87 percent kill in 3 days.

Three-Striped Blister Beetle

The adult beetles were fed either dusted or sprayed swiss chard leaves.

Semicarbazone	Dosage (micrograms per square centimeter)	Days exposed	Percent kill
4-Methylcyclohexanone	230	2	100
	-	4	100
Ethyl methyl ketone	250	2	100
	-	6	100
2,4-Dimethyl-3-pentanone	-	6	97
	280	2	96
2-Methylcyclohexanone	200	2	95
Cyclohexanone	200	2	90
p-Chloroacetophenone	-	6	87
Cyclopentanone	215	2	85
2-Furaldehyde	-	8	77
Cyclohexanone	-	6	76
Benzophenone	285	3	29
p-Chloroacetophenone	280	2	0
2-Furaldehyde	185	2	0

Three-Striped Blister Beetle--cont.

Semicarbazone	Dosage (micrograms per square centimeter)	Days exposed	Percent kill
2-Methylcyclohexanone	-	6	0
Salicylaldehyde	150	2	0
o-Veratraldehyde	260	2	0

Cabbage Looper

This test was conducted by feeding fifth instars dusted collard leaves. The only compound tested was p-chloroacetophenone semicarbazone, which at a dosage of 280 micrograms per square centimeter gave 4 percent kill in 2 days.

Codling Moth (9)

These tests were conducted on newly hatched larvae, by the apple-plug method, infested shortly after application. Each compound was sprayed at a concentration of 4 pounds per 100 gallons.

Semicarbazone	Percent wormy	Percent stung
p-Chloroacetophenone	7	21
2-Octanone	17	2
Cyclopentanone	21	0
2-Heptanone	30	0
2-Furaldehyde	35	21
4-Methylcyclohexanone	38	0
2-Methylcyclohexanone	42	0
Cyclohexanone	50	1
2,4-Dimethyl-3-pentanone	53	0
Ethyl methyl ketone	56	7
Cinnamaldehyde	66	0
Methyl propyl ketone	67	3
Salicylaldehyde	74	0
Benzophenone	76	0
4-Methyl-2-pentanone	76	0
o-Veratraldehyde	77	0
p-Hydroxyacetophenone	78	0
Acetoacetic acid, ethyl ester	79	3
alpha-Ethylbutyraldehyde	79	1
o-Chlorobenzaldehyde	82	0
p-Methylacetophenone	82	0
Crotonaldehyde	84	0
p-Aminobenzophenone	86	0
Benzoin	86	1
Levulinic acid	86	0
2,6-Dimethyl-4-heptanone	87	0

Codling Moth--cont.

Semicarbazone	Percent wormy	Percent stung
Acetophenone	88	0
Vanillin	88	0
Benzaldehyde	90	2
Piperonal	91	0
3,4-Dichloroacetophenone	92	2
Benzil (mono)	93	0
Acetonylacetone (di)	95	0

Cowpea Weevil

Adult weevils were exposed in a petri dish with peas sprayed with the compound at a concentration of 1:1000.

Semicarbazone	Days exposed	Percent kill
Methyl ethyl ketone	5	88
Methyl propyl ketone	5	78
Levulinic acid	4	77
Cyclopentanone	5	70
2,6-Dimethyl-4-heptanone	5	60
4-Methyl-2-pentanone	5	52
Salicylaldehyde	5	41
Cyclohexanone	4	33
Benzoin	4	26
2,4-Dimethyl-3-pentanone	4	22
3,4-Dichloroacetophenone	4	20
Benzophenone	4	19
2-Heptanone	4	14
Piperonal	4	7
Acetoacetic acid, ethyl ester	4	4
p-Chloroacetophenone	4	4
o-Chlorobenzaldehyde	4	4
p-Aminobenzophenone	4	3
Benzil (mono)	4	3
Acetophenone	4	0
2-Furaldehyde	4	0
Vanillin	4	0

Cross-striped Cabbageworm

Insects of the fifth instar were fed dusted collard leaves.

Semicarbazone	Dosage (micrograms per square centimeter)	Days exposed	Percent kill
Cyclohexanone	310	2	100
Cyclopentanone	200	3	100
Ethyl methyl ketone	280	2	100
2-Methylcyclohexanone	140	3	100
	-	6	100
4-Methylcyclohexanone	385	2	100
	-	4	100
Cyclohexanone	-	4	97
Cyclopentanone	-	6	65
2-Furaldehyde	165	3	37
2-Heptanone	435	3	23
2,4-Dimethyl-3-pentanone	150	3	13
Levulinic acid	420	2	7
p-Aminobenzophenone	340	3	0
Benzil (mono)	210	3	0
o-Chlorobenzaldehyde	270	2	0
3,4-Dichloroacetophenone	185	3	0
Piperonal	155	2	0

European Corn Borer (8)

Newly hatched larvae were fed sprayed cauliflower leaves. For the sake of comparison all results will be given at a concentration of 4 pounds per 100 gallons although further tests were made at a concentration as low as 1 pound per 100 gallons.

Semicarbazone	Days exposed	Percent kill
Acetophenone	3	99
Benzaldehyde	3	94
2,6-Dimethyl-4-heptanone	3	94
p-Chloroacetophenone	2	91
p-Methylacetophenone	3	76
Ethyl methyl ketone	3	11
Benzophenone	3	7
Cyclopentanone	3	6
4-Methyl-2-pentanone	3	3
Methyl propyl ketone	3	3
Piperonal	2	3
Salicyladehyde	3	3
Acetoacetic acid, ethyl ester	2	2
Acetonylacetone (di)	3	2
p-Aminobenzophenone	2	2
o-Chlorobenzaldehyde	2	2
Crotonaldehyde	3	2
3,4-Dichloroacetophenone	2	2
2,4-Dimethyl-3-pentanone	2	2
2-Heptanone	2	2
2-Methylcyclohexanone	2	2

European Corn Borer--cont.

Semicarbazone	Days exposed	Percent kill
2-Octanone	3	2
Vanillin	2	2
p-Aminobenzophenone	2	1
Benzil (mono)	2	1
Cyclohexanone	2	1
4-Methylcyclohexanone	2	1
o-Veratraldehyde	2	1
alpha-Ethylbutyraldehyde	2	0
Levulinic acid	2	0

Furniture Carpet Beetle (2)

The insects used were half-grown larvae. The results are given in terms of the ratio of the mortality produced by sodium fluosilicate solution to that produced by the compound.

Semicarbazone	Mortality ratio	Semicarbazone	Mortality ratio
p-Aminobenzophenone	1.4	Crotonaldehyde	8.0
p-Chloroacetophenone	1.4	o-Chlorobenzaldehyde	10.4
Benzophenone	1.5	Ethyl methyl ketone	10.6
Cyclohexanone	2.7	Acetoacetic acid, ethyl ester	10.7
Benzil (mono)	3.6	Piperonal	11.0
Acetophenone	4.1	Cyclopentanone	12.3
3,4-Dichloroacetophenone	4.2	p-Methylacetophenone	12.7
Benzaldehyde	4.6	Vanillin	13.0
Methyl propyl ketone	5.0	alpha-Ethylbutyraldehyde	14.0
2-Furaldehyde	6.5	Acetonylacetone (di)	18.2
2-Heptanone	7.0	2-Octanone	19.1
2,6-Dimethyl-4-heptanone	7.3	4-Methyl-2-pentanone	21.5
2,4-Dimethyl-3-pentanone	7.4	Salicylaldehyde	21.5

Hawaiian Beet Webworm (10)

The test insect was the fifth instar, which was fed dusted swiss chard leaves.

Semicarbazone	Dosage (micrograms per square centimeter)	Days exposed	Percent kill
p-Chloroacetophenone	-	4	100
Cyclohexanone	240	2	100
	-	4	100
Cyclopentanone	-	6	100
2-Methylcyclohexanone	-	6	100
4-Methylcyclohexanone	-	4	100

Hawaiian Beet Webworm--cont.

Semicarbazone	Dosage (micrograms per square centimeter)	Days exposed	Percent kill
p-Chloroacetophenone	385	3	96
Cyclopentanone	325	2	96
Ethyl methyl ketone	385	2	96
2-Heptanone	280	2	96
2,4-Dimethyl-3-pentanone	-	6	94
2-Furaldehyde	-	4	94
2,4-Dimethyl-3-pentanone	280	3	88
2-Furaldehyde	385	2	88
2-Heptanone	-	6	82
p-Aminobenzophenone	400	3	77
Salicylaldehyde	495	2	76
2,6-Dimethyl-4-heptanone	185	2	64
Methyl propyl ketone	280	2	48
Benzil (mono)	185	2	45
Benzophenone	340	2	40
Acetophenone	465	2	28
Crotonaldehyde	200	2	28
Acetoacetic acid, ethyl ester	215	2	12
3,4-Dichloroacetophenone	155	2	12
Benzaldehyde	185	2	8
alpha-Ethylbutyraldehyde	280	3	8
p-Hydroxyacetophenone	435	2	8
Salicylaldehyde	495	2	8
Benzoin	310	2	4
p-Methylacetophenone	355	2	4
4-Methyl-2-pentanone	185	2	4
Acetonylacetone (di)	170	2	0
Cinnamaldehyde	185	2	0
Piperonal	200	2	0

Imported Cabbageworm (10)

Fifth-instar larvae were fed dusted collard leaves for 2 days.

Semicarbazone	Dosage (micrograms per square centimeter)	Percent kill
2-Furaldehyde	385	96
Benzophenone	340	72
2,6-Dimethyl-4-heptanone	185	72
Acetophenone	465	44
Cyclopentanone	325	32
alpha-Ethylbutyraldehyde	280	30
Cinnamaldehyde	185	23
Benzaldehyde	185	16
Ethyl methyl ketone	385	16

Imported Cabbageworm--cont.

Semicarbazone	Dosage (micrograms per square centimeter)	Percent kill
Salicylaldehyde	495	16
Acetonylacetone (di)	170	12
Crotonaldehyde	200	12
p-Hydroxyacetophenone	435	12
4-Methyl-2-pentanone	185	12
p-Chloroacetophenone	280	8
p-Methylacetophenone	355	0
Methyl propyl ketone	280	0
2-Octanone	185	0

Looper

Fourth instars were fed sprayed collard plants.

Semicarbazone	Days exposed	Percent kill
2-Heptanone	6	67
Ethyl methyl ketone	6	54

Melonworm (10)

Fourth instars were fed dusted or sprayed pumpkin leaves.

Semicarbazone	Dosage (micrograms per square centimeter)	Days exposed	Percent kill
Cyclohexanone	355	3	100
2,4-Dimethyl-3-pentanone[1/]	-	4	100
2-Furaldehyde	-	4	100
Cyclopentanone	-	2	96
2,4-Dimethyl-3-pentanone	230	3	92
4-Methylcyclohexanone	356	3	87
p-Chloroacetophenone[1/]	-	7	79
	287	3	78
2-Methylcyclohexanone	-	6	73
p-Aminobenzophenone	370	3	72
2-Furaldehyde	435	2	72
Piperonal	230	3	72
4-Methylcyclohexanone	-	4	52
2-Methylcyclohexanone	385	3	44
2-Heptanone	280	3	34

[1/] Concentration 4 pounds per 100 gallons.

Melonworm--cont.

Semicarbazone	Dosage (micrograms per square centimeter)	Days exposed	Percent kill
Acetoacetic acid, ethyl ester	217	3	24
Cyclopentanone	325	2	24
Ethyl methyl ketone	385	2	24
Levulinic acid	450	2	16
Salicylaldehyde	230	2	12
Acetonylacetone (di)	215	2	8
alpha-Ethylbutyraldehyde	190	3	8
Crotonaldehyde	200	2	4
2,6-Dimethyl-4-heptanone	185	2	4
Methyl propyl ketone	280	2	4
Vanillin	230	2	4
Cyclohexanone	-	6	3
Ethyl methyl ketone	-	2	3
Acetophenone	340	2	0
Benzaldehyde	155	2	0
Benzil (mono)	170	2	0
Benzoin	355	2	0
Benzophenone	420	2	0
o-Chlorobenzaldehyde	495	2	0
Cinnamaldehyde	125	2	0
3,4-Dichloroacetophenone	155	2	0
p-Hydroxyacetophenone	250	2	0
p-Methylacetophenone	355	2	0
4-Methyl-2-pentanone	185	2	0
2-Octanone	185	2	0
o-Veratraldehyde	310	2	0

Mexican Bean Beetle (11)

Tests were conducted on fourth instars by the spray-tower petri-dish technique. A suspension of the compound in water containing 0.1 percent of acacia was used. Insects were exposed for 6 days.

Semicarbazone	Percent concentration	Percent kill
Ethyl methyl ketone	0.5	95
Cyclohexanone	1.0	92
Cyclopentanone	1.0	60
2-Furaldehyde	1.0	55
2,4-Dimethyl-3-pentanone	1.0	37

Mosquito Larvae (1)

Tests were conducted on fourth instars by the standard laboratory method. The concentration was 100 parts per million in all cases, and the exposure time was 40 hours except for alpha-ethylbutyraldehyde, when it was 16 hours.

Semicarbazone	Percent kill	Semicarbazone	Percent kill
alpha-Ethylbutyraldehyde	100	p-Hydroxyacetophenone	3
Salicylaldehyde	50	Acetonylacetone (di)	0
2,6-Dimethyl-4-heptanone	18	Benzaldehyde	0
Cinnamaldehyde	7	Crotonaldehyde	0
p-Methylacetophenone	4		

Okra Caterpillar

Three-fourths grown insects were fed dusted okra leaves. Insects were exposed 3 days.

Semicarbazone	Dosage (micrograms per square centimeter)	Percent kill
p-Chloroacetophenone	400	100
2,4-Dimethyl-3-pentanone	285	100
4-Methylcyclohexanone	210	93

Rice Weevil

Adult insects were fed wheat sprayed with the compound at a concentration of 1:1000.

Semicarbazone	Days exposed	Percent kill
Methyl propyl ketone	5	30
Ethyl methyl ketone	5	25
Levulinic acid	4	9
Cyclohexanone	4	5
p-Chloroacetophenone	4	4
2,4-Dimethyl-3-pentanone	4	4
p-Aminobenzophenone	2	3
Cyclopentanone	5	3
2-Furaldehyde	4	3
2-Heptanone	4	3
4-Methyl-2-pentanone	5	3
Acetoacetic acid, ethyl ester	4	2
Benzil (mono)	4	2
Acetophenone	4	0
Benzoin	4	0
Benzophenone	4	0
o-Chlorobenzaldehyde	4	0
3,4-Dichloroacetophenone	4	0
2,6-Dimethyl-4-heptanone	5	0
Piperonal	4	0
Salicylaldehyde	5	0
Vanillin	4	0

Screwworm (7)

The jar method was used on newly hatched larvae.

Semicarbazone	Minimum lethal concentration (Percent)
Benzophenone	0.01 - 0.025
2,6-Dimethyl-4-heptanone	0.01 - 0.025
Acetophenone	0.05 - 0.01
Crotonaldehyde	0.05 - 0.01
Cyclohexanone	0.05 - 0.01
2,4-Dimethyl-3-pentanone	0.05 - 0.01
2-Furaldehyde	0.05 - 0.01
Cyclopentanone	0.01 - 0.166
Ethyl methyl ketone	0.01 - 0.166
2-Heptanone	0.01 - 0.166
Levulinic acid	0.01 - 0.166
2-Methylcyclohexanone	0.01 - 0.166
4-Methylcyclohexanone	0.01 - 0.166
Methyl propyl ketone	0.01 - 0.166
4-Methyl-2-pentanone	0.166 - 0.34
alpha-Ethylbutyraldehyde	0.34 - 0.666
Acetoacetic acid, ethyl ester	Slightly toxic at 0.666
Acetonylacetone (di)	Slightly toxic at 0.666
Benzaldehyde	Slightly toxic at 0.666
2-Octanone	Slightly toxic at 0.666
p-Aminobenzophenone	Nontoxic at 0.666
Benzil (mono)	Nontoxic at 0.666
Benzoin	Nontoxic at 0.666
p-Chloroacetophenone	Nontoxic at 0.666
o-Chlorobenzaldehyde	Nontoxic at 0.666
Cinnamaldehyde	Nontoxic at 0.666
3,4-Dichloroacetophenone	Nontoxic at 0.666
p-Methylacetophenone	Nontoxic at 0.666
Piperonal	Nontoxic at 0.666
Salicylaldehyde	Nontoxic at 0.666
Vanillin	Nontoxic at 0.666
o-Veratraldehyde	Nontoxic at 0.666

Southern Armyworm

Fourth instars were fed dusted or sprayed collard leaves.

Semicarbazone	Dosage (micrograms per square centimeter)	Days exposed	Percent kill
2,4-Dimethyl-3-pentanone	195	2	100
	-	2	100
2-Methylcyclohexanone	385	3	100
4-Methylcyclohexanone	356	2	100
2-Methylcyclohexanone	-	6	97

Southern Armyworm--cont.

Semicarbazone	Dosage (micrograms per square centimeter)	Days exposed	Percent kill
4-Methylcyclohexanone[1/] (See page 8.)	-	5	91
p-Chloroacetophenone	385	2	33
Cyclohexanone	-	4	30
Ethyl methyl ketone	-	4	19
Cyclopentanone	-	6	9
p-Chloroacetophenone	-	4	8
Cyclopentanone	345	2	7
2-Furaldehyde	-	4	4
Acetoacetic acid, ethyl ester	213	2	0
Acetonylacetone (di)	230	2	0
Acetophenone	503	2	0
p-Aminobenzophenone	400	2	0
Benzaldehyde	225	2	0
Benzil (mono)	185	2	0
Benzoin	510	2	0
Benzophenone	500	2	0
o-Chlorobenzaldehyde	250	2	0
Cinnamaldehyde	240	2	0
Cyclohexanone	240	2	0
3,4-Dichloroacetophenone	155	2	0
2,6-Dimethyl-4-heptanone	185	2	0
alpha-Ethylbutyraldehyde	265	2	0
Ethyl methyl ketone	535	2	0
2-Furaldehyde	510	2	0
2-Heptanone	280	2	0
2-Hydroxyacetophenone	365	2	0
4-Methyl-2-pentanone	250	2	0
Methyl propyl ketone	385	2	0
2-Octanone	230	2	0
Piperonal	230	2	0
Salicylaldehyde	580	2	0
Vanillin	355	2	0
o-Veratraldehyde	240	3	0
Crotonaldehyde	155	2	0

Squash Bug

Second instars were dusted directly and fed untreated pumpkin leaves.

Semicarbazone	Dosage (micrograms per square centimeter)	Days exposed	Percent kill
Cyclohexanone	425	1	4
p-Chloroacetophenone	355	2	0
2,4-Dimethyl-3-pentanone	310	2	0
Ethyl methyl ketone	440	2	0
2-Furaldehyde	525	2	0

Termites

Adult insects were placed on treated soil. All results are given at a concentration of 1:1000.

Semicarbazone	Days exposed	Percent kill
2-Octanone	2	100
p-Chloroacetophenone	4	52
Benzophenone	4	43
p-Hydroxyacetophenone	3	29
4-Methyl-2-pentanone	3	26
2,4-Dimethyl-3-pentanone	4	24
2-Methylcyclohexanone	1	13 (1:5000)
Cyclohexanone	2	12
Ethyl methyl ketone	3	9
o-Veratraldehyde	4	3
Acetonylacetone (di)	3	0
Acetophenone	3	0
Benzaldehyde	3	0
Benzoin	3	0
Crotonaldehyde	3	0
Cyclopentanone	3	0
2,6-Dimethyl-4-heptanone	3	0
alpha-Ethylbutyraldehyde	3	0
2-Furaldehyde	4	0
2-Heptanone	4	0
p-Methylacetophenone	3	0
Methyl propyl ketone	3	0
Salicylaldehyde	3	0

Yellow Woollybear

Benzophenone semicarbazone was the only compound tested against this insect. Fourth instars were fed dusted collard leaves at a dosage of 335 micrograms per square centimeter and gave a 44 percent kill after 3 days' exposure.

Summary of Results

All compounds were considered toxic to leaf-eating insects if they gave at least 75 percent kill. In the case of the codling moth, those that gave less than 50 percent of wormy fruit were included. For the screwworm all compounds having a minimum lethal concentration of 0.1 percent were chosen. Other results were selected on a similar basis.

The following list includes all semicarbazones that were definitely toxic to one or more insects and the number of species to which each was toxic:

Semicarbazone	Number of species	Semicarbazone	Number of species
Cyclohexanone	8	2,6-Dimethyl-4-heptanone	2
4-Methylcyclohexanone	8	Levulinic acid	2
p-Chloroacetophenone	7	Methyl propyl ketone	2
Cyclopentanone	6	2-Octanone	2
2,4-Dimethyl-3-pentanone	6	p-Aminobenzophenone	1
Ethyl methyl ketone	6	Benzaldehyde	1
2-Furaldehyde	6	Crotonaldehyde	1
2-Methylcyclohexanone	6	alpha-Ethylbutyraldehyde	1
2-Heptanone	3	2-Methylacetophenone	1
Acetophenone	2	Salicylaldehyde	1
Benzophenone	2		

It is noteworthy that, of the 33 semicarbazones tested, 21 showed definite toxicity to 1 or more insects. Of the 8 most toxic compounds, 4 are semicarbazones of cyclic aliphatic ketones, and they were the only compounds of this group which were tested. Aside from these, no particular group stands out. However, there seem to be some differences in toxicity exhibited by small differences in composition in some groups. For example, of 7 semicarbazones of ketones containing an aromatic group, p-chloroacetophenone semicarbazone was found to be the most effective. 3,4-Dichloroacetophenone semicarbazone was entirely ineffective, and other substituted acetophenone and benzophenone semicarbazones were not so toxic as acetophenone and benzophenone themselves.

Of 7 aliphatic ketone semicarbazones, 5 showed some toxicity, and 2 of these, 2,4-dimethyl-3-pentanone semicarbazone and ethyl methyl ketone semicarbazone, were among the most effective materials tested.

In general, it may be concluded that semicarbazones as a group show promise as insecticides against selected insects.

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